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Original Article

How critical is the effect of body mass index in physical fitness and physical activity performance in adolescents

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Abstract
The objective of this study was to analyze the effect of body mass index in physical fitness and physical activity in adolescents. A total of 426 adolescents aged from 10 to 17 years performed physical fitness battery tests, filled in a physical activity questionnaire and anthropometric measurements were completed. A total of 24.5% adolescents are overweight or obese. From General Linear Model test, statistically significant differences ($p=0.000$) were found between body mass index groups for all physical fitness tests with exception of the flexibility and upper body strength tests. A significant negative Spearman's correlation $r = -0.016$ ($p \leq 0.05$) was found, suggesting that adolescents with a small amount of weekly physical activity level reveal the greatest body mass index percentiles. The overweight or obese condition significantly affects the adolescent's performance during the physical fitness tests. About 39% of adolescents reported no physical activity outside school. Inactivity is more common among girls (46%) than boys (33%).
Key Words: *fitness tests, scholars, nutritional status, physical activity assessment*

Introduction

Overweight and obesity conditions have increased globally among children, adolescents and adults. Childhood obesity is associated with increased cardiovascular mortality and morbidity in adult life. Evidence suggests that non-physically active children or adolescents are more likely to become non-physically active adults, and encouraging the development of physical activity (PA) habits in children could help to establish patterns that remain into adulthood (Watts, Jones, Davis, & Green, 2005).

PA results in increased capacity and physical fitness (PF), which may lead to many health benefits. Numerous studies have suggested that PF and/or habitual PA have, or potentially have, positive impacts on health and longevity (Aires, Silva, Silva, Santos, Ribeiro & Mota, 2010; Marta, Marinho & Marques, 2012; Ortega, Ruiz, Castillo & Sjöström, 2008; Ruiz, Castro-Piñero, Artero, Ortega, Sjöström & Castillo, 2009). In fact, two important behaviours linked with lifestyles are strongly linked with the energy balance: i) the physical activity level and sports activities (Aires et al., 2010; Godina, Khomyakova, Purundzhan, Tretyak & Zadorozhnaya, 2007; Parikh and Stratton, 2011); ii) the energy intake that is associated to food habits, and the suitable micronutrient supply must be in similar proportion to energy expenditure (Burke, Beilin, Milligan & Thompson, 1995).

During adolescence, PA is thought to influence growth and development of skeletal bone, muscle mass and fat (Fogelholm, 2008). Moreover, a low level of PA has been associated with an increased prevalence of obesity (Berntsen et al., 2010; Fogelholm, 2008) but, the reduced energy expenditure itself cannot explain the gain of fat mass during growth (Johnson et al., 2000). On the other hand, increased levels of PA are associated with a lower body mass index (BMI) (Berkey, Rockett, Gillman & Colditz, 2003; Berntsen et al., 2010) and fat mass (Godina et al., 2007) in children and/or adolescents.

Nevertheless, the impact of the adolescent's BMI in physical fitness level is not well known. Due to this fact, the main purpose of this study was to analyze the body mass index (BMI) correlation to physical fitness (PF) and physical activity levels (PA) in overall adolescents from a public middle school.

Material & methods

Design, setting, and participants

The sample comprised all the 450 adolescent students from a public middle school located in Viseu, a city of the center of Portugal. A total of 426 adolescents (182 girls and 244 boys) aged from 10 to 17 years (mean 12.2 ± 1.6 years) were included. Fifteen adolescents did not attend the anthropometric day measures and nine did not present valid PA questionnaires, and were therefore eliminated from the study.

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Anthropometry

To achieve the diagnosis of adolescent's nutritional status, anthropometric data for weight and height were collected just before the physical fitness tests.

In order to measure body weight an electronic balance-type platform with capacity for 150 Kg and 100 g intervals (Tanita TFB-521®) was used. All adolescents dressed light clothes and were weighted without shoes. The height of adolescents was measured using a stadiometer (Seca®) fixed to the wall with a scale in millimeters (mm). Two measurements were carried out and the average values obtained were considered.

Nutritional status was determined using BMI. BMI expresses the weight-for-height relationship as a ratio, that is, weight (in kilograms)/[height (in meters)]^2 or (BMI = Kg/m^2). Participants were classified into underweight (<P5), eutrophic (≥P5 and <P85), overweight (≥P85 and <P95) and obese (≥P95) according to age and sex specific cut-off points proposed by the North American BMI latest reference (NHANES, CDC, USA).

Physical Fitness Tests Battery

A battery of six physical fitness tests (FITNESSGRAM®, The Cooper Institute for Aerobics Research) was applied at the beginning of the scholar year between September and October, during the physical education classes.

The anthropometric data followed by the aerobic fitness test were obtained during a 45 min physical education classe. The other measurements were done during a 90 min physical education classe, following the sequence: 1st global flexibility, 2nd strength tests, and 3rd speed test.

Measurements

1. One mile test

The aerobic fitness was evaluated by standardised mile (1609 meters) running test, respecting the following protocol: participants executed one mile distance running faster as possible without any stops. They were instructed to only slower the pace after finishing the distance. Photoelectric cells (Digest 1000, Digest Oy, Finland) were used at the beginning and at the end of the course to improve the accuracy of the measure. The time was recorded for data analysis.

2. Speed test

Speed was evaluated by 40 meters maximal sprints, according to the following protocol – participants executed two maximal 40 m sprints, with 3 minutes rest interval between each sprint. The adolescents started to run one meter before the photoelectric cells and they only slowed after they passed by the second pair of cells. The best of the two obtained times was recorded for data analysis (Aguiar et al., 2008).

3. Strenght tests

3.1. Lower body strength - horizontal jump

The participants were standing both feet together and parallel with the tips of the feet in the row zero distance. With the help of arms, jumped as far as possible, and should balance in the reception foot position. The valid measure point was the first tip of the heel and the better of the two obtained distances was recorded for data analysis.

3.2. Medium strength – 30'' abdominal

The student is placed in a lying back position, with legs bend forming an angle of 90º. The arms are raised over the trunk with the palms facing the floor in which the bending of the change is made until the fingers touch the tips of his/her own heel. The feet of the student were fixed by a colleague who was also counting the number of pushups performed during the test.

3.3. Upper body strength – launch the medicinal ball

The adolescent is standing with one foot in front of the other; the foot in front is next to the zero. He/she holds a medicine ball with both hands near the chest, runs a full extension of the arms throwing the ball up and forward, as far as possible, keeping the balance. The balls weight was used in accordance to their sex and age. The best of the two obtained distances was recorded for data analysis.

3.4. Global flexibility – seat-and-reach test

The adolescents, from a seated position with their backs against the wall, legs together and in full extension, keeping the arms extended and hands as an extension of the arms, should reach in front as far as possible. Measured is the distance between the initial position of the fingertips (zero reference) and the position of the fingertips in maximum reach. The best of the two distances was recorded for data analysis.

Procedures of the physical activity questionnaire application

Overall, 426 adolescents completed an original self-administered questionnaire and all questionnaires were considered valid to this study. Only adolescents born in Portugal were considered. The questionnaires consisted of several multiple choice questions and were completed at school, in October of 2008, during a 20-min session. All participants were assured that their responses were both voluntary and anonymous.

The self-applied questionnaire contained two different main sections of questions: Section A, about information on personal data collected by means of 7 questions; Section B, about lifestyle healthy habits and it included 2 questions about physical activity habits outside school.

Human subjects' approval statement

The protocol used during the present study was approved by the Pedagogic Council (institutional review board) of the school were the study was conducted before data collection. The study was conformed to the declaration of Helsinki and both parents and participants were informed of the objectives, procedures, potential discomfort and benefits before given written informed consent.

Statistical analysis

All statistical analyses were performed using SPSS v. 16.0 (SPSS Inc., Chicago, IL). Descriptive statistics such as the means, percentages and frequencies were used to summarize the data. Spearman rank correlation test and one-way ANOVA by General Linear Model (GLM) were also performed with SPSS v. 16.0 software. All data undergoing GLM were tested for assumptions of normality, homogeneity of variance and covariance matrices and sphericity. Neither assumption was violated. Statistical significance was set at 5%.

Results

From the total of adolescents (42.7% girls and 57.3% boys) the prevalence of underweight was 2.4% of boys between 11 and 14 years, and 2.1% of girls, between 10 and 12 years and one single case at the age of 15 (Table 1).

Table 1 - Classification of adolescents' BMI by gender and by age.

Anthropometric status		Gender				Total	
		Boys		Girls			
	Age	n	%	n	%	n	%
Underweight (<P5)	10	0	0.0	1	0.5	1	0.2
	11	2	0.8	2	1.1	4	0.9
	12	1	0.4	1	0.5	2	0.5
	13	2	0.8	0	0.0	2	0.5
	14	1	0.4	0	0.0	1	0.2
	15	0	0.0	1	0.5	1	0.2
	16	0	0.0	0	0.0	0	0.0
	17	0	0.0	0	0.0	0	0.0
Eutrophic (≥P5 and <P85)	10	31	12.7	20	11.0	51	12.0
	11	32	13.1	37	20.3	69	16.2
	12	31	12.7	25	13.7	56	13.1
	13	39	16.0	21	11.5	60	14.1
	14	28	11.5	24	13.2	52	12.2
	15	12	4.9	4	2.2	16	3.8
	16	1	0.4	3	1.6	4	0.9
	17	2	0.8	1	0.5	3	0.7
Overweight (≥P85 and <P95)	10	4	1.6	6	3.3	10	2.3
	11	9	3.7	4	2.2	13	3.1
	12	7	2.9	4	2.2	11	2.6
	13	7	2.9	4	2.2	11	2.6
	14	6	2.5	2	1.1	8	1.9
	15	1	0.4	2	1.1	3	0.7
	16	0	0.0	0	0.0	0	0.0
	17	0	0.0	0	0.0	0	0.0
Obese (≥P95)	10	8	3.3	5	2.7	13	3.1
	11	5	2.0	3	1.6	8	1.9
	12	3	1.2	6	3.3	9	2.1
	13	8	3.3	4	2.2	12	2.8
	14	3	1.2	2	1.1	5	1.2
	15	1	0.4	0	0.0	1	0.2
	16	0	0.0	0	0.0	0	0.0
	17	0	0.0	0	0.0	0	0.0

From General Linear Model (GLM) univariate test, statistically significant differences (p=0.000) were found between BMI percentiles groups for all physical fitness tests with exception for flexibility and upper body strength tests.

Figure 1A and Figure 1B shows that obese adolescents were slower in aerobic fitness and speed tests comparing to other groups. However, in the 15 year old, the groups of underweight and overweight were slower in the speed test than the obese ones.

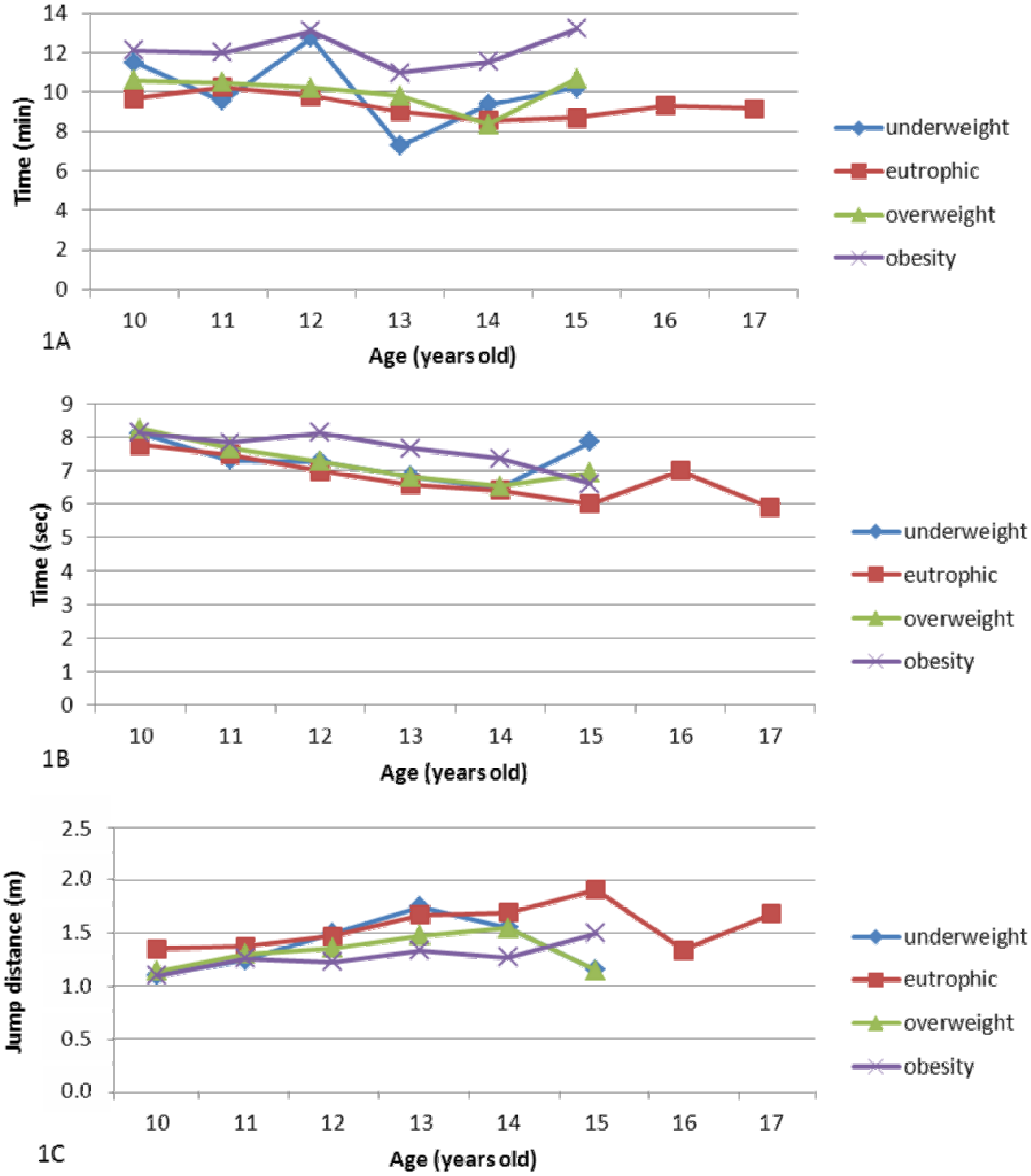

Fig. 1 – (A) Test of aerobic fitness (miles – 1609 m). (B) Speed test (40 m). (C) Lower body strength, horizontal impulse (jump the feet together).

According to the Figure 1C, all other groups present better results in lower body strength than the obese group with the exception of 15 years. In this case, as verified in the previous speed test (Figure 1B) the underweight and overweight groups had worst jump performance. Figure 2A shows very similar results with the previous test. Indeed, the obese group showed the weakest performance when submitted to the medium strength abdominal test in almost all ages with the single exception of the 15 year individuals.

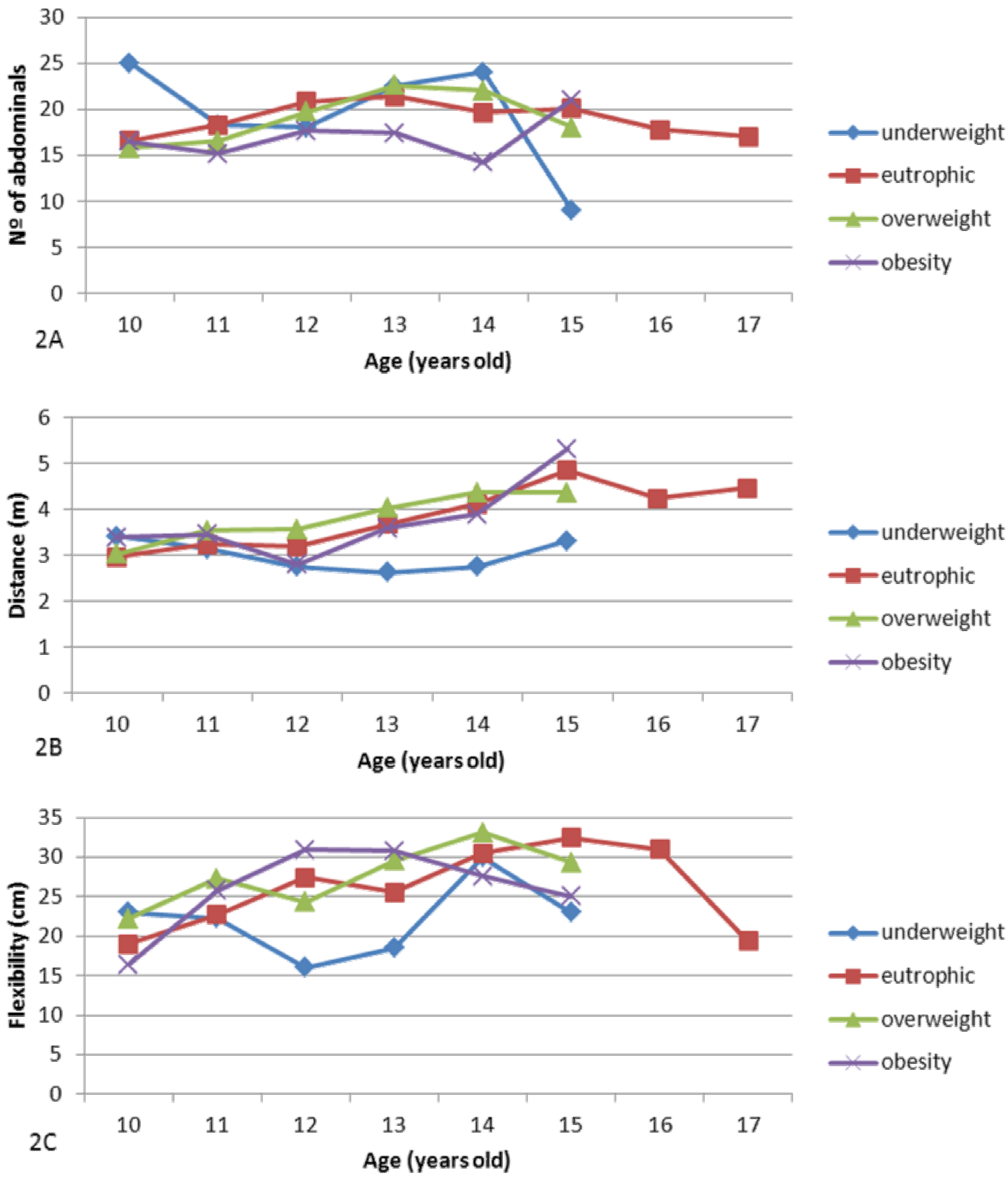

Fig. 2 – (A) Medium strength – 30 s abdominal. (B) Upper body strength – launch the medicinal ball. (C) Global flexibility (seat-and-reach).

Figures 2B and 2C show that, no differences were found between obese group and other groups, when upper body strength and flexibility are contrasted. Moreover, the underweight group showed the worst upper body strength results between 13 and 15 years sample. This last group also revealed weak flexibility performance between 12 and 13 years.

From the total of 426 adolescents, 60% attested the sport activity engagement outside the school. Considering the physical activity outside the school by gender, 66% of boys and 54% of girls practice any physical activity. From this data we can observe that boys are more active outside the school than girls. In the present study, 63.6% to 70.0% of adolescents (aged between 11 and 15 years) have at least one physical activity outside the school.

The Spearman rank correlation test was calculated between the BMI percentiles and the weekly frequency of physical activity. A significant negative Spearman's correlation r = -0.016 ($p \leq 0.05$) was found, suggesting that to greatest BMI percentiles corresponds adolescents with a small sport index number of physical activities outside the school per week.

Discussion

Considering the normal nutrition status, we can observe that 72.1% boys and 74.0% girls, in a total of 73.0% of adolescents, showed an acceptable and healthy nutritional status.

Taking into account the overweight condition, 14.0% boys and 12.1% of girls (aged between 10 and 15 years) were in that situation. Finally, 11.4% of boys between 10 and 15 years and 10.9% of girls between 10 and 14 years, showed an obesity nutritional status.

Overall, adolescents in overweight and obesity conditions comprise a total of 25.4% of boys and 23.1% of girls, which makes a total of 24.5% of the studied population. Furthermore, 2.6% of students presented a low weight condition that could probably reflect nutritional deficiencies.

The present study shows that the obesity condition in Portuguese school adolescents is high and reaffirms what other authors have observed in similar population groups. For example, in a previous study related to BMI and overweight in adolescents (aged 13 and 15 years) in 13 European countries, Israel and United States, the authors found overweight and obesity prevalence of of 16.0% and 19.5% for boys (13 and 15 years, respectively) and 31.1% and 27.5% for girls (13 and 15 years, respectively) in Portugal (Lissau et al., 2004).

Recently, Sardinha et al. (2010) found in a representative sample of adolescents between 10 and 18 y of age that the prevalence of overweight and obesity by the IOTF criteria (Cole, Bellizzi, Flega & Dietz, 2000) in Portuguese center region was lower than what can be observed in the present study, 21.8% in boys (against 25.4%) and 19.9% in girls (against 23.0%). In the present study 13.2% of the total adolescents are overweight and 11.3% are obese. In total, 24.5% of all adolescents are overweight or obese. Moreover, the prevalence of a greater percentage of boys with overweight or obesity is similar in these Portuguese studies. Also in Spain, a study with 3534 children and adolescents between 2 and 24 years revealed that the prevalence of obesity was superior in males (15.6% vs. 12.0% in girls (Serra et al., 2003). This remark from these studies differs from other studies conducted by other authors who suggest that the prevalence of overweight and obesity in girls is greater (Magarey, Daniels & Boulton, 2001; Martínez et al., 2002).

The adolescents considered in the present study have 135 minutes of weekly physical education, divided by 2 lessons: a lesson of 90 minutes and another of 45 minutes according to the curriculum established by the Portuguese Ministry of Education (ME, 2010). However, it can be verified by the high percentage of overweight and obesity found, that the time and frequency of physical activity at school is insufficient to ensure a normal healthy weight.

A recent study showed that it is important to improve the perception of physical education as a subject and its teaching staff as factors which help to achieve a healthier lifestyle (Nuviala, Gómez-López, Turpin & Nuviala, 2011). Fogelholm, Stigman, Huisman & Metsämuuronen (2007) studied the associations of overweight (BMI $\geq 85^{th}$ percentile) and physical activity (PA) with physical fitness in 15-16 years adolescents. Physical fitness was measured by sit-ups, sit-and-reach, five-jump, back-and-forth jumping, ball skills, coordination and endurance shuttle run tests. The prevalence of overweight was 17.3% in boys and 11.8% in girls. Through linear regression models, these authors reached the conclusion that, the association between PA and fitness was stronger than that between overweight and fitness.

The conclusions reached with the previous physical fitness tests are in complete agreement with studies of other authors that found that during adolescence, overweight and obesity are often a burden that results in psychosocial problems (Strauss, 2000) and a reduced capacity for exercise (Molnár and Livingstone, 2000).
For example, Bourdeaudhuij et al. (2005) showed that overweight adolescents do less intense physical activities ($p < 0.001$). Furthermore, since the assessment of PF is one of the components that contribute to physical education final classification, the results of overweight and obese ones may weigh negatively in their final grade. The possible relationship between physical fitness results and academic performance should be studied in future studies.

The lower sport activity in girls compared to boys is also supported by previous studies from other countries in Europe (Ferron, Michaud, Narring & Cauderay, 1997; Hurson and Corish, 1997). Koezuka et al. (2006) in their study to evaluate the relationships between the time spent on sedentary activities (computer, video games, television, and reading) and physical inactivity in a sample of 7982 adolescents (4034 males and 3948 females, aged 12-19 years), found that 50.3% of boys and 67.8% of girls were inactive.

In the present study, 63.6% to 70.0% of adolescents (aged between 11 and 15 years) have at least one physical activity outside the school. The results found are very encouraging and indicate a positive behaviour of these adolescents that need to be reinforced continuously during their lives. The results are converse to those found in USA among children aged 9-13 years (CDC, 2003), which indicated that 61.5% of children do not participate in any organized physical activity during their non-school hours and that 22.6% do not engage in any free-time physical activity.

Considering the adolescents that have at least one physical activity outside school, it was verified that football/futsal, swimming, bicycle riding and athletics are the most practiced sports outside school.

Unfortunately, 39% of the adolescents revealed that they do not have any physical exercise or sport activity outside school. This sedentary behaviour is very worrying and could be one of the causes for the high levels of overweight and obesity found in the group of adolescents under study. Improving levels of physical activity of these adolescents will require innovative solutions that motivate them.

In a study with a randomized sampled of 114 boys (9.4 ± 1.5 years) the exercise and sports enhancement outside school schedule (at least 3h per week) promote a positive effect on body composition, and seems to be efficient to reduce the percentage of body fat and the limbs and trunk region fat mass (Ara et al., 2004).

An important strength of the present study is that physical fitness data were obtained under controlled conditions which improved their reliability. Moreover, all these physical fitness tests were previously performed (Aguiar et al., 2008). A limitation of this study was the use of a self-administered questionnaire because they can have some bias that is difficult to determine or avoid.

The results of this study were explained to the adolescents and their parents in order to make them aware and alert to the need of modifying risk behaviors that lead to obesity status. This work also led to the development of a guideline by the school board to appeal to the greater involvement of the whole school community in the promotion and practice of healthy lifestyles.

Conclusions

To summarize, the present research highlighted that the overweight or obese condition significantly affects the adolescent's performance during the PF tests. It is well recognised that PA confers to adolescents many health benefits. By this reason, public schools should increase opportunities for regular PA (outside physical education classes) for all students. Hence, it will be of a great importance if middle and high schools create a multidisciplinary office to plan specific exercise programs to improve PA and also nutritional advisement to overweight and obese adolescents.

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